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Development of a Mentorship Program in Engineering and Engineering Technology

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DEVELOPMENT OF A MENTORSHIP PROGRAM IN ENGINEERING AND ENGINEERING TECHNOLOGY

Abstract

This paper discusses feasible means of integrating mentorship programs into engineering and engineering technology curricula. The two main motivations for investigating the development of such programs are to improve retention rates and to augment the efforts toward increasing the enrollment of minority students. In fact, it can be argued that a mentorship program can also indirectly assist in the achievement of critical student outcomes for accreditation. The model of mentorship presented in this paper involves a vertical integration of cohorts through a series of project-based learning (PBL) courses. Furthermore, this attempt is enhanced by the introduction of incentives that encourage student involvement in undergraduate research as well as on-campus engineering organizations. The specific focus of the mentorship is on student-student relationships in addition to the conventional faculty-student relationships. These relationships allow students to learn from each other since they are able to strongly relate to each other's experiences among their peer group. The mentoring model proposed in this paper formulates a learning community that allows the student to form a support group and a mechanism for preventive intervention, as discussed in other studies on mentoring programs. Such student engagement is commonly acknowledged to significantly benefit the students as well as the student mentors involved in the program. Data from an initial student survey that measures the efficacy of the proposed mentorship program is included in this paper and these data are discussed in detail. A 1-5 Likert scale is used for quantitative analysis of the data in order to evaluate the self-efficacy of the program. The group size of the mentorship cohort has been limited to a maximum of thirty students at this stage. Preliminary analysis of the data indicates that the participating students have a strongly positive opinion of the program.

Keywords: Mentorship, Engineering, Project-based Learning (PBL).

1. Introduction

Mentoring is commonly acknowledged as a means of creating a learning relationship in which individuals share their professional experiences with learners.[1,2] Mentors are individuals with experience and knowledge who are committed to support the advancement of the mentee. The nature of the relationship can differ from one group to another due to possible differences in the composition of the mentoring group. However, a mentoring relationship is widely accepted to enhance career and personal development of the mentee. The relationship is typically informal since the mentor does not act as a supervisor and since the mentor does not expect a financial reward in return. In an academic institution, the mentoring relationship is often misunderstood as a relationship involving academic advising. Although academic advising may constitute a component of a mentoring relationship, mentoring is understood to go above and beyond the semester by semester advising on program requirements, required courses, etc.

The recent focus on attracting minorities, females as well as ethnic minorities, to engineering and technology programs has necessitated a need to look for the reasons that may be responsible for low minority representation in these programs.[3] Also, academic institutions have been considering wide ranging means of encouraging more and more of these students to enroll, and more importantly, to stay with these programs. These programs are commonly acknowledged to be challenging with students required to go through a steep learning curve during their first year at the university while catching up with mathematics and physics courses that are often pre-requisites for engineering courses in the sophomore year. Student perceptions about engineering and engineering curriculum can vary significantly depending on the exposure that freshmen students may have had prior to starting an undergraduate engineering program. Students often start these programs with pre-conceived notions about engineering and are sometimes discouraged by the mathematics and physics requirements which they don't associate directly with engineering. This misconception could be mitigated by systematically introducing the students to the larger picture of the curriculum as well as the engineering program and career possibilities. In this paper, a mentoring program is presented that is expected to increase retention in engineering programs by enhancing the student preparation for the junior and senior level courses while allowing them to clearly see multiple career opportunities that can be pursued with engineering and technology degrees.

Project-based learning (PBL) is recognized as a high-impact practice that enhances student learning and strongly motivates students.[4,5] PBL allows students to learn through practice, with open-ended projects and assignments that could have multiple solutions. In some of the tasks associated with the projects, the instructor becomes a facilitator and is not necessarily a content expert. This approach makes application of the concepts learnt in the class more important than a mere repetition of the content in an assignment. PBL also allows incorporation of oral and written communication components into the course through required presentations, project reports, team meetings and interactions. The application and hands-on components of PBL are especially crucial in an applied science programs such as engineering and engineering technology, and are even included in program outcomes for accreditation.[6]

This paper proposes a model for a mentorship program that integrates a sequence of PBL courses to enhance student-student mentoring relationships that are further reinforced by faculty-student relationships. The model also integrates the use of student organizations, opportunities for undergraduate research and other campus resources to motivate the students and provide further opportunities for students to form informal mentoring relationships. The mentorship model is discussed in Section 2. Preliminary data collected from one such program that has been initiated is presented in Section 3. Section 4 discusses the results and provides overall conclusions with a future scope for this study.

2. Mentorship Model

The mentorship model proposed in this paper is based on the development of a cohort from multiple engineering and technology students ranging from freshmen to seniors. The main intent is to formulate a student-student mentorship model where students can learn from each other's experiences since they can easily relate to these experiences.[7,8,9] Furthermore, a group of faculty members provides the conventional faculty-student mentorship. This mentorship is expected to

go beyond the typical advising relationship where a student is advised on the set of courses that need to be taken in the subsequent semester. This mentorship relationship allows the faculty members to share industry experiences, research experiences and university experiences with the students from time to time. A vertical integration between students at different stages of their university experience in conjunction with the faculty mentorship is expected to significantly overcome some of the issues associated with students expressing a lack of confidence and a lack of sense of belonging, as reported in relevant literature.[7] Peer mentoring is seen as a critical factor in enhancing the social and academic confidence of mentees, particularly among freshmen students.[8] Studies in the existing literature also point out overall psychological and career benefits of mentorship to minority students in technical areas of study.[9]

Fig. 1 shows a layout of the mentoring structure adopted in this study. This mentoring model develops a cohort of students consisting of freshmen, sophomore, junior and senior students. This vertical integration allows the students to discuss issues such as difficulty with college level math, difficulties with balancing their schedules, etc. Often times, the junior and senior students can mitigate some of the anxieties of the freshmen and sophomore students by describing their own experiences and the means by which they overcame some of the problems.[8,9] This is typically accomplished in sessions where students are given a theme or a topic that they discuss among themselves. The faculty mentors reiterate some of the points discussed among students and then use the talking points for a broader dialog with the students who are being individually mentored by the faculty members. The faculty mentorship often involves discussion of such topics as difficulties with course content, involvement with student volunteer groups and professional societies, involvement with undergraduate research, internship opportunities, industry expectations, graduate studies, use of campus resources like the tutoring center and career services, etc. Such mentoring sessions are scheduled once a month. The faculty advisement is typically associated with program requirements, course registration, course pre-requisites and course planning. Individual advisement is generally done once a semester.

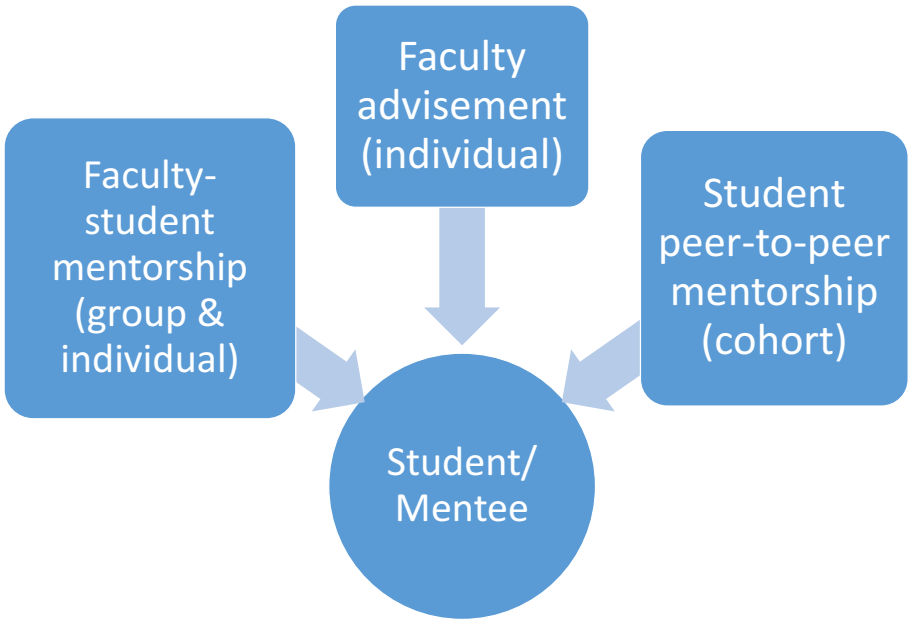

Fig. 1. Mentoring Structure.

While academic advisement is a very common component in most of the engineering programs, integration of the advisement with the other two components shown in Fig. 1 allows the mentee to form a trusting relationship with the faculty mentor as well as the student cohort. These relationships allow the formation of a robust support group that is particularly crucial in the first year of an engineering program since most of the retention issues are known to emerge during this time.[3,10]

The student cohort component of the mentorship model is further strengthened by integrating a project in the PBL courses for the freshmen and sophomore students with junior and senior students respectively for four to six weeks of the semester. This component is incorporated to enhance student engagement while preparing the freshmen and sophomore students for the open-ended, challenging courses in the junior and senior years. It may be noted that the sequence of PBL courses is a required component of the curriculum for all students. Since the group is relatively small, each group consists of three to four student mentors and three to four student mentees. At this stage, the mentor/mentee groups have been matched to have some multidisciplinary representation. In the future, academic standing and ethnic diversity will also be considered while matching the mentor/mentee groups.

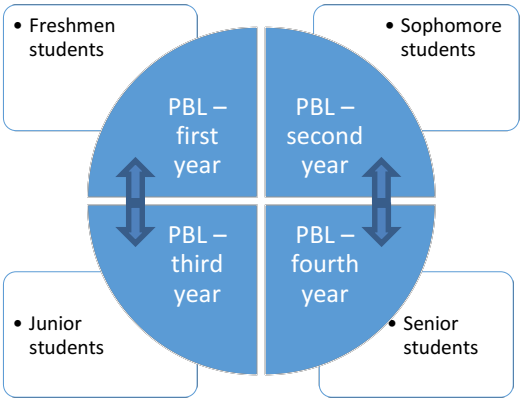

Fig. 2. Student peer-to-peer mentorship.

The logistics of implementing the model shown in Fig. 2 can be challenging and need to be carefully planned in order to maximize student learning from the integration. As a result, student expectations are clearly laid out before the commencement of the assigned projects. The freshmen and junior students are provided with a set of guidelines by the instructor and the expectations from the two groups are distinct. While the junior students have to deliver an alpha prototype at the end of the semester, the freshmen students support the junior students during the development and, in the process, understand the importance of concept development, project planning, etc. The freshmen students do not get graded on the delivery of the alpha prototype but instead submit a report and make a presentation. The instructor schedules some initial sessions to organize the teams and to make arrangements for the groups to interact and distribute the project content so that the students are aware of their roles. Students are also encouraged to exchange contact information so that they can meet outside the class to make progress with the project before the subsequent group meetings.

The nature of the integration between the sophomore and senior students is slightly distinct, and is not as interactive as the one discussed above. The sophomore students are required to attend some of the presentation sessions and group meetings of the senior students (working on their Capstone projects). They are also required to attend the poster presentation session made by the senior students at the culmination of their Capstone project. The sophomore students are required to write reflection papers to explain their experience and to explain their understanding of the project. The main rationale behind this interaction is to introduce the sophomores to the open-ended, and often vague, project objectives of the Capstone projects. Furthermore, the interaction between the groups is somewhat limited to prevent burdening the senior students.

The peer-to-peer mentorship is considered to be critical since students are expected to relate to each other's experiences and such relationships are expected to encourage students to engage in co-curricular activities such as student competitions or engineering clubs, etc. Such activities are reported in the literature to significantly enhance levels of engagement among students.[8,9] The student mentors are expected to benefit by having multiple opportunities to explain their work to the student mentees. This interaction is expected to provide student mentors with opportunities to reflect on their projects.

The final component of the mentorship program is a requirement that all participating students need to fulfil. This requirement involves active association of the students with an engineering organization on campus or involvement in an undergraduate research project. For this requirement, students may or may not be working with their mentor. However, they need to report to their mentor at the end of the semester with a brief report and a presentation that highlights the main achievements of their work. Student projects may range from involvement with organizations such as SAE Mini Baja or IEEE Robotics to specifically working in a research laboratory on campus or assisting a faculty member with research. This activity is specifically aimed at stimulating student interest in out-of-class activities. Benefits of such co-curricular activities are widely reported in the literature.[11]

3. Data Collection and Results

This section discusses the results from the assessment of efficacy of the mentorship program conducted during Fall 2014. All the students participating in this data collection were in the mentorship program discussed in the previous section. The total number of students in the mentorship program represents approximately 6% of the students in engineering and technology programs (with a total of 517 students in academic year 2014-15). It is acknowledged that the sample size is pretty low at this stage. However, after preliminary results from this study are available, the mentorship program can be extended to cover a larger percentage of students. It may be noted that the institution is classified as a regional comprehensive master-granting university with a Carnegie Community Engagement classification. A preliminary analysis was performed to evaluate the data collected to assess the efficacy of the mentorship program, and is discussed in this section. It may be additionally noted that the student peer-to-peer mentorship (shown in Fig. 2) has not been evaluated yet. This will be done over the next few years.

The data collection was performed in Fall 2014 among a group of students selected for a scholarship. The data collection was conducted two times, first during the eighth week of classes

and then during the fourteenth week of classes. The first round of data collection was conducted to perform a pilot study and to detect any possible problems or ambiguity with the survey instrument. As a result, these data have not been used for analysis. All the data presented in this paper are based on the second round of data collection, conducted during the last week of classes. Participation in the survey used for data collection was voluntary and participating students were required to sign an informed consent form that was approved by the Institutional Review Board (IRB) of the university. A request for Human Subjects Research was submitted to the IRB at the university, and an approval was obtained earlier during the semester after completing the required training. The survey was completed by the participating students through the selection of one out of five possible responses to each question. The survey was only conducted in the print format and participating students were given a five minute background about the study. Students were asked to respond to the following (eleven questions) in the questionnaire:

1. Mentors have helped me in understanding engineering careers.
2. Mentors have helped me to understand the skills needed in engineering.
3. Mentors have helped me to appreciate the need for specific engineering courses.
4. Mentors have helped me to appreciate the need for a combination of design, analysis and hands-on skills.
5. Mentors have helped me to acquire skills by closely observing peers and senior students.
6. Mentors have exposed me to possible opportunities (careers, internships, research, industry, campus resources).
7. Mentors have helped me to learn from other students' experiences.
8. Mentors have exposed me to ideas and concepts that I may not learn in the classroom.
9. Mentors have helped me to see the need for communication skills.
10. Mentors have helped me to see the need to strive to learn continuously.
11. Mentors have helped me to understand the importance of engaging in research projects.

All the survey responses are quantified using a 1-5 Likert scale, with 1 representing a very high level of agreement with the survey question and 5 representing a very high level of disagreement with the survey question. The 1-5 scale allows a quantitative analysis of the data in addition to a general subjective analysis of the responses obtained from the survey questionnaire. This 1-5 scale will be used throughout this section for analyzing the results from the survey. In order to maximize the sample size for this study, all the students in the mentorship program were requested to participate in this study. A total of 26 students participated in the final survey, all the participants were part of a scholarship program and have declared an engineering or an engineering technology program as their major area of study. All the data collected from the survey is presented in the Appendix for reference.

Some of the responses to the survey questions are shown in Fig. 3 to Fig. 6. Specific questions have been selected to demonstrate responses to some aspects of the mentorship program. The percentage of students strongly agreeing (Likert scale 1) or agreeing (Likert scale 2) to Question # 1 (about understanding engineering careers) is 96, as shown in Fig. 3. It is important for students to understand the diversity of career opportunities within engineering since they may have a limited understanding based on their exposure or perceptions. Student responses demonstrate that the mentorship program has been successful in explaining possible career paths.

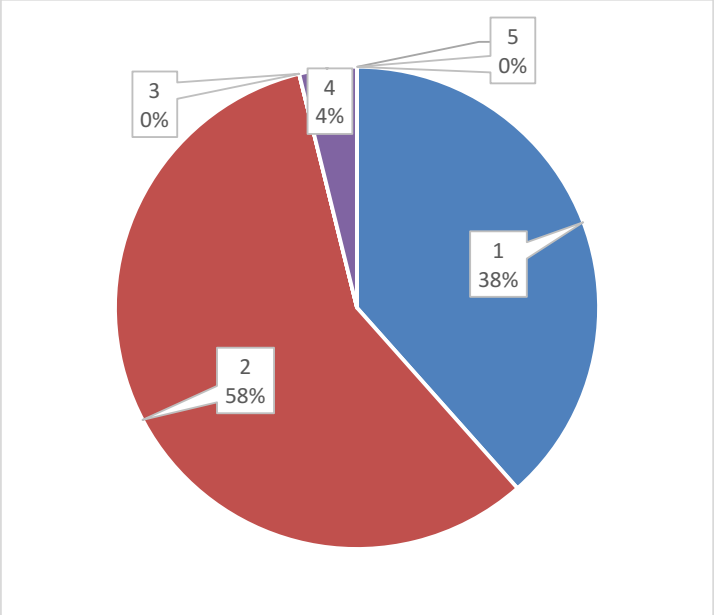

Fig. 3. Survey Response – Question # 1.

Fig. 4 shows that 81% of the students strongly agree (Likert scale 1) or agree (Likert scale 2) with the mentorship program enabling them to learn from the experiences of other students (Question # 7). This is a critical aspect of the mentorship program proposed in this paper and will be strengthened further over the next few years of this program.

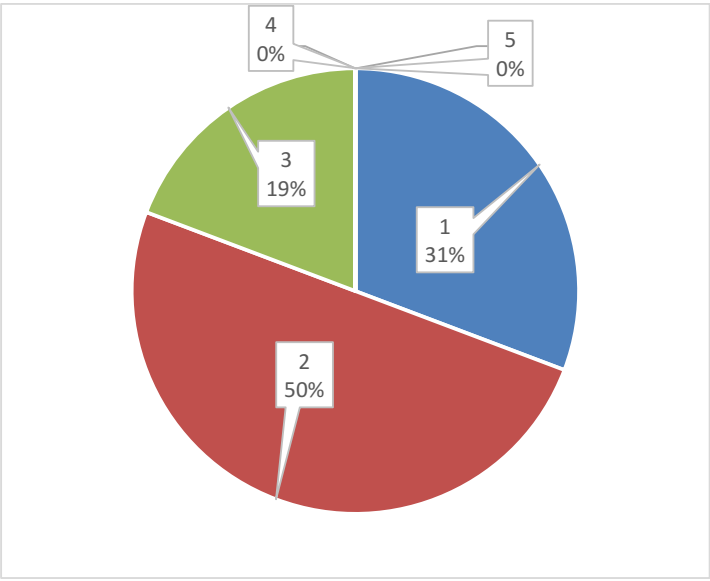

Fig. 4. Survey Response – Question # 7.

Fig. 5 demonstrates strong agreement (Likert scale 1) or agreement (Likert scale 2) with the exposure to possible opportunities (Question # 6), with 96% of the students agreeing or agreeing strongly.

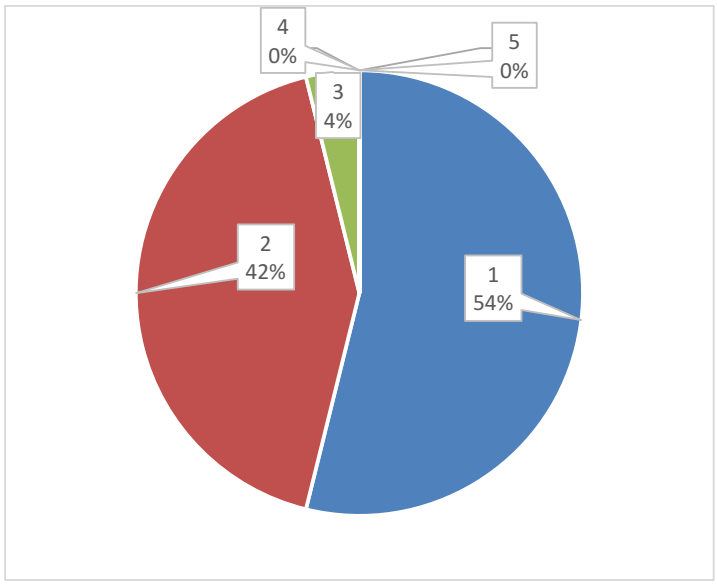

Fig. 5. Survey Response – Question # 6.

Some areas of improvement can also be discerned from the survey response. Response to Question # 5 reveals that 27% of the students did not indicate that they have acquired skills by observing peers and senior students, as shown in Fig. 6. This may be primarily attributed to the fact that vertical integration through the PBL courses has not yet been incorporated into the program. This will be done over the subsequent semesters and it is expected that students will start observing the benefits of this integration.

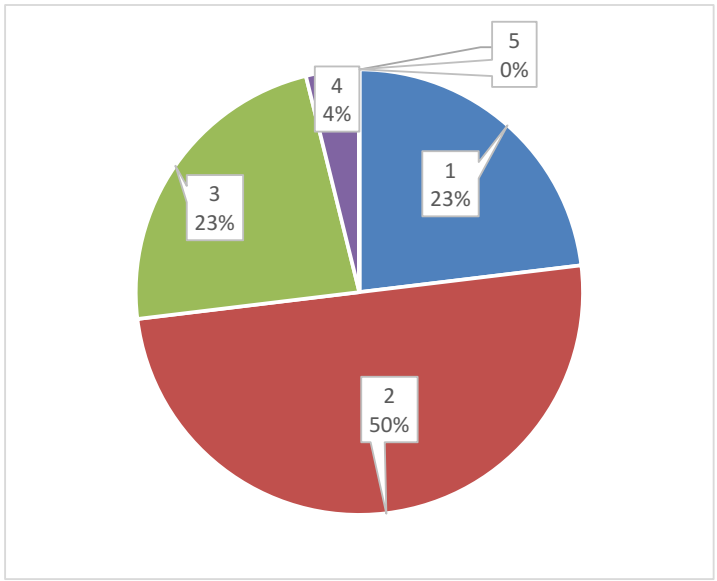

Fig. 6. Survey Response – Question # 5.

The overall weighted response to all the survey questions, except Question # 5, is between 1.46 and 1.88. This indicates that students generally agree or strongly agree with the attributes of the mentorship program. Some subjective comments have also been sought from the participating

students at the end of the semester to understand student perceptions and also to seek student inputs on how the mentorship experience can be further enhanced over the upcoming semesters. Most of these comments are positive with a few students expressing a need for events such as field trips to local industry. Such events will be organized in the future by closely coordinating with local chapters of engineering organizations.

4. Discussion and Conclusions

The mentoring program proposed in this paper presents an attempt to enhance student engagement by allowing students to see beyond the day-to-day course work. The program proposes a unique integration of student-student mentoring, faculty-student mentoring, advising and extra-curricular activities. The long term goal of this program is to substantially increase retention rates and on-time graduation rates in the engineering disciplines. The rigor of engineering programs and a loss of confidence due to challenging math and physics content, particularly at the freshmen level, are widely reported as some of the main factors behind low retention rates.[12] The mentorship program proposed in this paper aims at mitigating this phenomena to some extent by comprehensively involving students in a few activities and forming a supporting cohort. This cohort is expected to allow students to gain confidence by relating to similar experiences of senior students and also by allowing the students to see engineering applications directly from junior and senior students. Such an informal mentorship model has been reported to be significantly effective in the existing literature, particularly among minority students.[13,14] It is expected that this program will serve as a model that can be adapted in the future to enhance the number of minority students in engineering programs.

The assessment of efficacy of the mentorship program by the students presents an opportunity to comprehend whether students themselves see the benefits of mentoring. It is observed that the participating students have a very positive opinion of the program, as demonstrated by the data collected for this paper. However, this data is preliminary and needs to be followed up by tracking student progress over a few years and by periodically monitoring the performance of the students participating in the mentorship program. This will be done in the future to comprehensively assess the efficacy of all the different components of the overall mentorship program proposed in this paper. Outcomes of the mentorship program will be assessed over the next two years. Furthermore, benefits of the program to senior and junior students (student mentors) who may be mentoring the sophomore or freshmen students will also be evaluated in the future in order to seek possible means of improving the model proposed in this paper.

References

1. DuBois, D. L., Holloway, B. E., Valentine, J. C., Cooper, H., 2002, "Effectiveness of Mentoring Programs for Youth: A Meta-Analytic Review," American Journal of Community Psychology, 30, pp. 157-197.
2. Allen, T. D., Eby, L. T., 2003, "Relationship Effectiveness for Mentors: Factors Associated with Learning and Quality," Journal of Management, 29, pp. 469-486.
3. Marra, R. M., Rodgers, K. A., Shen, D., Bogue, B., 2012, "Leaving Engineering: A Multi-Year Single Institutional Study," Journal of Engineering Education, 101, pp. 6-27.

4. Bender, W. N., 2012, “Project-Based Learning: Differentiating Instruction for the 21st Century,” Corwin Press.
5. Boss, S., Krauss, J., 2007, “Reinventing Project-Based Learning,” International Society for Technology in Education, Eugene, OR.
6. ABET, Engineering Accreditation Commission, 2010, “Criteria for Accrediting Engineering Programs,” ABET Inc, Baltimore, MD.
7. Parsons, S., Croft, T., Harrison, M., 2011, “Engineering students’ self-confidence in mathematics mapped onto Bandura’s self-efficacy,” Engineering Education, **6**, pp. 52-61.
8. Doherty, A., 2013, “Peer Mentoring and Professionalism,” Proceedings of the HEA STEM Conference, The Higher Education Academy, doi:10.11120/stem.hea.2013.0033, pp. 163-167.
9. Hill, R., Reddy, P., 2007, “Undergraduate peer mentoring: an investigation into processes, activities and outcomes,” Psychology Learning and Teaching, 6, pp. 98-103.
10. Baker, J. G., Finn, M. G., 2008, “Can a Merit-Based Scholarship Program Increase Science and Engineering Baccalaureates?” Journal for the Education of the Gifted, 31, pp. 322-337.
11. Wilson, D., Jones, D., Kim, M. J., Allendoerfer, C., Bates, R., Crawford, J., Floyd-Smith T., Plett, M., Veilleux, N., 2014, “The Link between Cocurricular Activities and Academic Engagement in Engineering Education,” Journal of Engineering Education, 103, pp. 625-651.
12. Meyer, M., Marx, S., 2014, “Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering,” Journal of Engineering Education, 103, pp. 525-548.
13. Rose, B. R.., Cotton, J. L., 1999, “Mentor Functions and Outcomes: A Comparison of Men and Women in Formal and Informal Mentoring Relationships,” Journal of Applied Psychology, 84, pp. 529-550.
14. Denson, C. D., 2010, “Impact of an Engineering Mentorship Program on African-American Male High School Students’ Perceptions and Self-Efficacy,” Journal of Industrial Teacher Education, 47, pp. 99-127.

Appendix

The data collected from all the respondents who participated in this study is presented in the Appendix in Table A.1. It may be noted that the numbers provided in Table A.1 correspond to the total number of respondents strongly agreeing (1), or agreeing (2), or neither agreeing/nor disagreeing (3), or disagreeing (4), or strongly disagreeing (5) to specific questions in the survey discussed in Section 3.

Table A.1. Data Collection.

	Survey Response					
Q	1	2	3	4	5	Overall Response
1	10	15	0	1	0	1.69
2	10	13	3	0	0	1.73
3	9	11	6	0	0	1.88
4	12	13	1	0	0	1.58
5	6	13	6	1	0	2.08
6	14	11	1	0	0	1.50
7	8	13	5	0	0	1.88
8	15	9	1	1	0	1.54
9	15	10	1	0	0	1.46
10	16	6	4	0	0	1.54
11	9	17	0	0	0	1.65
					Mean	1.69
					Std. Dev.	0.18
					Median	1.65